

Beamline 1.4: Advances in Infrared Research and Instrumentation

The Fourier-transform infrared (FTIR) spectromicroscopy beamline, Beamline 1.4.3, has served many ALS users. The heaviest interest to date comes from the biological and environmental science fields. Two outstanding examples of how this beamline can be used to investigate biochemical changes within individual living human cells are described in detail in the Science Highlights Section (page 30).

In 2000, we continued our efforts to optimize the infrared spectroscopy program for biomedical

applications. The funding of a DOE grant to investigators Hoi-Ying Holman, Michael Martin, and Wayne McKinney will allow the purchase of improved equipment designed with the biological scientist in mind. SSG members also carried out a test of key importance to the biological community, showing that the synchrotron infrared beam does not appreciably heat biological samples. Synchrotron infrared spectroscopy at the ALS can therefore truly be called a nondestructive technique.

The diffraction-limited spot size and high signal-to-noise ratio available on this beamline have enabled research in a wide variety of fields in addition to those mentioned above. These include subjects as diverse as development of lithium-ion batteries for use in hybrid electric vehicles, laser irradiation of dental tissues, studies of the strongly correlated material SrRuO_3 , the chemistry of ink, and laser-driven phase transformations in fused silica. Studies were also carried out on basalt assemblages at high pressures (see Figure 2), organic matter and contaminants on sediments, fingerprints, and bacteriorhodopsin microcrystals. Other studies have involved supercooling of water, classification of cell populations with genomic data, microdistribution of trace elements in a high-boron soil, the biochemistry of bacteria attached to basalt, radiative properties of polar bear hairs, and root-derived biopolymers.

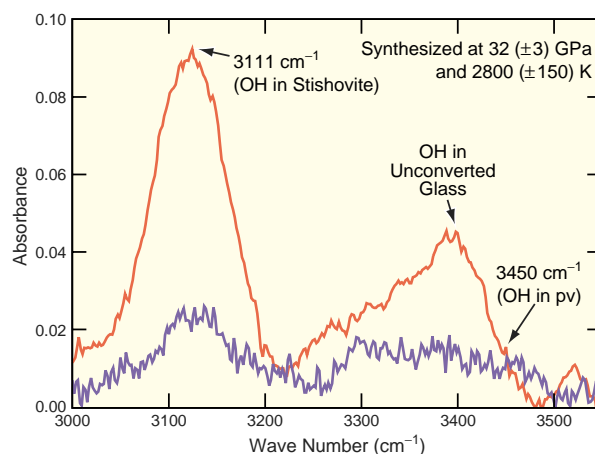


Figure 2 Comparison of a spectrum taken at Beamline 1.4.3 (*red*, 256 scans) to one taken on a lab-based spectrometer (*blue*, 60,000 scans). While both show a distinct peak at 3111 cm^{-1} corresponding to OH vibrations in stishovite, the synchrotron-based spectrum has a much better signal-to-noise ratio as well as better spatial resolution, thereby avoiding problems of sample heterogeneity. (From W.R. Panero, L.R. Benedetti, R. Jeanloz.)

Work has continued on making the infrared beamline facilities as user friendly as possible. This has included completing the installation of a four-axis active feedback system, which reduces the low-frequency noise on the beam and keeps the position of the diffraction-limited infrared spot fixed in space from day to day. Software is also being developed to aid in the analysis of the large numbers of spectra typically acquired in an infrared mapping.

Beamline 4.0.2 : Elliptical Polarization Undulator Helps Detect Dichroism

Beamline 4.0.2 is the first undulator beamline at the ALS equipped with a Sasaki-type elliptical polarization undulator (EPU). The EPU allows full control of the polarization of the x rays, from linear horizontal to helical to linear vertical, making it a unique tool to study dichroic effects, especially magnetic circular and linear dichroism. The undulator, in combination with a plane-grating, variable-included-angle monochromator, is designed to provide high-flux photon beams from 50 eV to 2000 eV. This

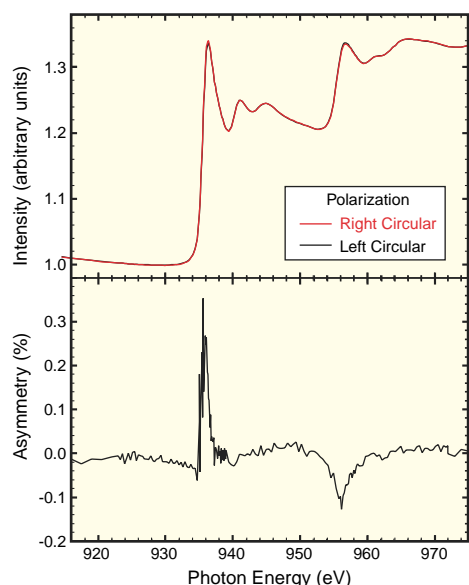


Figure 3 First measurements of dichroism at Beamline 4.0.2. Total-electron-yield spectra were obtained from a multilayer sample consisting of 10-Å-thick layers of a $\text{Co}_{90}\text{Fe}_{10}$ alloy alternating with 13-Å-thick layers of copper. The adjacent $\text{Co}_{90}\text{Fe}_{10}$ layers induce a small magnetic moment of approximately $0.01\mu_B$ in the copper spacer layer. This can be observed as a small magnetic circular dichroism effect in the copper $L_{2,3}$ absorption spectra.

provides full coverage of the $L_{2,3}$ edges of important magnetic transition metals (Fe, Co, Ni) and also the $M_{4,5}$ edges of magnetic rare-earth elements of interest (Gd, Tb, etc.).

Figure 3 shows some of the first measurements of small magnetic circular dichroism effects made at this facility. The sample contained alternating layers of $\text{Co}_{90}\text{Fe}_{10}$ and copper. Total-electron-yield spectra at the copper $L_{2,3}$ absorption edge were taken by switching (within two seconds) the polarization of the x rays at each photon energy, thus eliminating the influence of any long-term instabilities of the system from the dichroism signal. These experiments were performed by F. Nolting et al. (ALS, Stanford Synchrotron Radiation Laboratory).

Beamline 7.0.1: Investigating Novel Materials

Photoemission spectroscopy at Beamline 7.0.1 made an order-of-magnitude improvement in efficiency this year with the deployment of an SES-100 imaging spectrometer (Figure 4) to replace the



Figure 4 The upgraded high-resolution photoemission chamber on Beamline 7.0.1: (A) new SES-100 imaging spectrometer with (B) differentially pumped rotary seal around its lens; (C) new liquid-helium cryostat and goniometer.